

Can Computer Use on the Farm Build Skills for Off-Farm Jobs?

The increasing use of computers on the farm raises the question of whether these new skills will be valued in off-farm employment. Data suggest that computers are used predominantly for a single group of tasks that may not develop the “systems skills” that are becoming increasingly important in off-farm employment.

Off-farm employment by farm operators and their spouses has been a key to financial survival for farm families. The mechanization of farms earlier in the 20th century gave farmers mechanical and problem-solving skills that were prized by many rural employers, largely in manufacturing and related industries that needed workers who were good at operating and repairing machinery. Many skills learned on the farm were transferable to nonfarm jobs. Those skills made the transition to nonfarm careers easier for farm youth and helped farmers in finding off-farm jobs.

As the United States moves from an industrial to an “information economy,” demand for workers with mechanical skills is stagnant or declining. Many employers now seek computer skills and the ability to find and process information. Will farmers be as employable off the farm as they were in the past? Will farming communities participate in the information economy, or will they be left behind?

Onfarm Computer Use Increasing

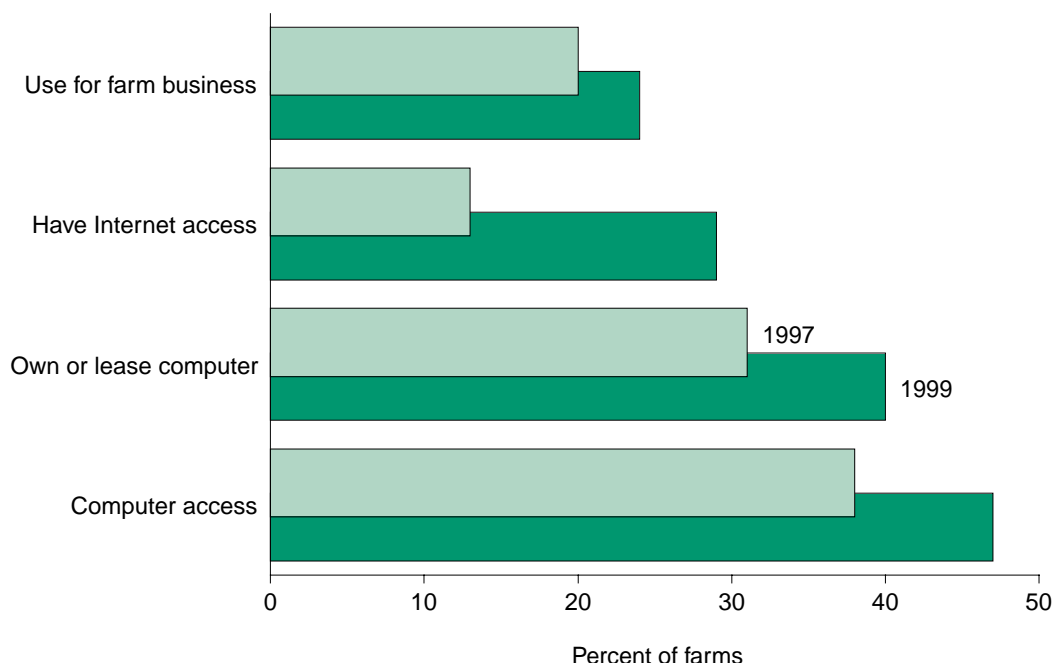
To a large extent, farms have also been participating in the information revolution. A recent USDA survey shows that nearly half of farms reported using computers in 1999 (fig. 1). Comparison with 1997 data suggests that onfarm computer use is growing rapidly. In the 2 years between 1997 and 1999, farms with access to a computer increased from 38 to 47 percent.

Internet access more than doubled in the same 2-year period, rising from 13 percent of all farms in 1997 to 29 percent in 1999. Unfortunately, these data do not include informa-

Figure 1

Farm computer use, 1997 and 1999

Computer use on the farm grew considerably between 1997 and 1999; Internet access doubled



Source: *Farm Computer Usage and Ownership*, National Agricultural Statistics Service, Agricultural Statistics Board, USDA, July 1999.

tion on the percentage of farms using this technology to get up-to-the-minute market information, to get technical information related to farming problems, or to interact electronically with suppliers or customers. However, the growth in access of itself is an important development as the usefulness of the Internet to the farm business is likely to be discovered over time. Strong sales of books such as *The Farmer's Guide to the Internet* (<http://www.rural.org/favorites.html>) along with the emergence of search engines devoted to agriculture (for example, The AgriSurfer available at <http://www.AgriSurfer.com>) suggest that many farmers are actively investigating these possibilities.

The percentage of farms using computers in the farm business in 1999 was only 24 percent and also grew at a more modest rate over the 2 years. This finding suggests that roughly half the farm households with computer access are using computers as a consumer good or for nonfarm business. The data suggest that only half of farms with access to computers use them for farm business applications.

Larger farms are more likely to have computer access and—if they have access to a computer—more likely to use computers for farm business (fig. 2). The benefits of integrating computers are more likely to exceed the costs of purchasing and learning to use them on large farms. The wide diffusion of computer technology—oftentimes used first in nonfarm activities—bodes well for the eventual use of computer technology across the farm size spectrum.

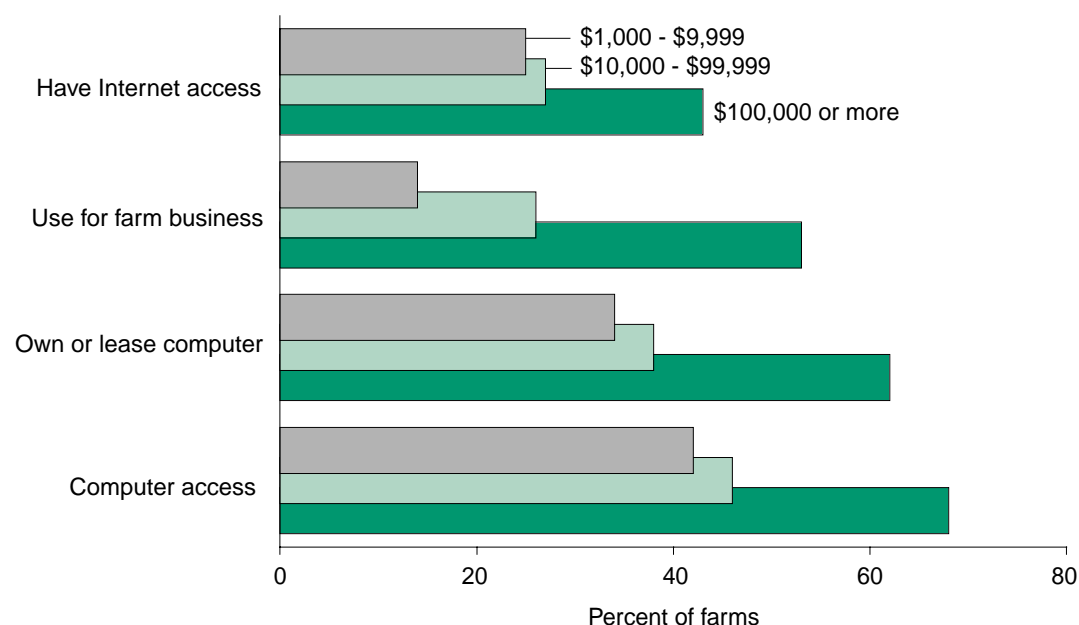
A more detailed account of the specific computer applications used in the farm business is available in the *1995 Agricultural Resource Management Study*. While the data are relatively old, they can tell us which applications are most common in the farm business and provide more detailed characteristics of farmers and farm households associated with computer use.

Computerized bookkeeping/financial analysis was by far the most common application across all farm types. For farm sizes up to \$500,000 in sales, bookkeeping/financial analysis applications were roughly twice as prevalent as 'Computer software for production decisions,' the second most common application. Computer-aided chemical applica-

Figure 2

Farm computer use by farm sales class, 1999

Computer use is more likely on larger farms



Source: *Farm Computer Usage and Ownership*, National Agricultural Statistics Service, Agricultural Statistics Board, USDA, July 1999.

tions/field operations were infrequent for farms as a whole (2.5 percent) but used by 15-20 percent of farms in the two largest size classes. In contrast, using global positioning systems to aid field operations was infrequent across all size classes. Unfortunately, the data provide no information on the use of electronic market information either through the Internet or subscription services.

The data confirm that large farms, and those run by younger farm managers with a college degree, are most likely to use computers in the farm business. Both farm size and educational attainment of the farm operator produce striking differences in the rate of adoption. Farmers with a college degree are roughly 10 times more likely to use the various applications compared with farmers with less than a high school diploma. These factors are equaled or exceeded in comparing the smallest farm size class (less than \$50,000 in sales) with the largest farm size class (more than \$1,000,000). The increasing age of the farm operator has a more modest effect on reducing the likelihood of using the various applications.

Computers Underused

As of 1995, for each sales class, age group, and educational level, relatively few farms used computers for production operations (table 1). This suggests that the majority of farms using computers are not integrating this use across production and accounting required of a farm management information system.

A less comprehensive but more recent 1998 survey of U.S. corn growers by Novartis, Inc., provides more timely information on the adoption of 'precision agriculture' technologies such as Global Positioning System (GPS) mapping and yield monitors (table 2). However, these statistics are not a representative sample of all farms, and may overstate computer use compared with the 1999 USDA data. In the one comparable data item, computer use in the farm business is reported as 24.1 percent in the 1999 NASS/USDA data but 46.2 percent in the Novartis data. Despite this inconsistency, the Novartis data suggest that applications providing detailed information on the characteristics and variability of small plots within a field have been adopted by many farms in the two largest size categories. The data also provide information on the percentage of farms with Internet access that are using this technology in the farm business. Over all size classes, 21.1 percent of farms are using the Internet to retrieve agricultural information.

While these more recent data suggest a greater prevalence of computer use in production decisions than did the 1995 data, the Novartis data also give the general impression that computers are not being fully exploited to integrate information from diverse aspects of the farm operation. Roughly 46 percent of all farms use a computer in the farming operation, but less than half of those farms use the informational capabilities of the Internet for production or marketing. An even smaller percentage of farms use precision agriculture technologies.

Skill Requirements of Information-Intensive Farming

The increasing use of computers in farm businesses is encouraging. It suggests that farm managers are using some of the same information technologies that are also being used in the wider economy. However, the question remains whether farmers using computers on the farm will develop skills that are valued in the off-farm economy. Is it enough for farmers to be 'computer literate' or does the information economy require a broader suite of skills?

Some experts emphasize that worker skill development is no longer confined to classrooms. Both managers and frontline workers must continuously develop new skills by learning on the job. A traditional allure of farming has been the combination of mental and physical activity that values this ability to learn by doing. In the past, this mode of learning was farm-specific. However, if the capability to learn from farming operations is substantially augmented by the application of information technology, then skills developed using this new tool may also be valued in off-farm employment. That is, the concrete experience

Agriculture and the Rural Economy

Table 1

Computer applications of farmers by size of operation and operator characteristics, 1995

Bookkeeping/financial analysis is the most commonly used application

Item	Computerized bookkeeping/ financial analysis	Computer software for production decisions	Computer-aided chemical application/ field operations	Global Positioning System to aid field operations
Percent of responding farms				
Farms using technology	14.6	6.5	2.4	0.8
Sales class:				
Less than \$50,000	8.7	2.7	1.0	.3*
\$50,000 or more	31.3	17.4	6.3	2.1
\$50,000 - \$99,999	20.1	11.5	3.7*	1.6**
\$100,000 - \$249,999	31.6	16.3	5.3	1.4*
\$250,000 - \$499,999	43.5	22.7	10.5	3.7
\$500,000 - \$999,999	54.2	35.3	14.6	6.2
\$1,000,000 or more	71.2	51.6	20.3	4.2*
Operator age:				
Less than 35 years	21.3	11.4	5.3	1.8*
35 to 44	23.3	12.2	2.9	.9*
45 to 54	17.4	7.0	2.5	.5*
55 to 64	11.6	4.7	1.9	.9*
65 years or older	5.4	1.5	1.3*	.5**
Operator education:				
Less than high school	2.5	1.5*	.8*	.1**
High school	9.6	4.1	1.5	.5*
Some college	20.2	9.1	3.8	1.4*
College	33.3	14.8	4.5	1.4*

Note: About 3.5 percent of farm operators refused to answer these questions. Excludes cooperative farms.

* The relative standard error (RSE) of the estimate exceeds 25 percent, but is no more than 50 percent. The RSE provides a means of evaluating the survey results. A smaller RSE indicates greater reliability of the data. Estimates with RSE's of 25 percent or less are not marked.

** The relative standard error of the estimate exceeds 50 percent, but is no more than 75 percent.

Source: USDA, Economic Research Service, 1995 *Agricultural Resource Management Study*, Farm Operator Resources version only.

Table 2

Technologies used by U.S. corn growers by size of operation, 1998

Computer use is most common on larger farms

Computer technology	Acres per farm				
	Total	50-249	250-499	500-999	1,000 or more
Percent					
Personal computer (PC)	55.6	46.2	60.4	72.7	78.4
PC for farming operation	46.2	37.6	49.2	61.5	67.2
Internet for agriculture information	21.1	15.2	24.3	29.8	39.7
Global Positioning System (GPS)	12.2	7.2	12.3	21.6	33.9
Yield monitor on combine	16.0	8.1	18.8	27.6	47.5
Monitor tied to GPS	4.5	1.3	3.8	8.6	26.2

Source: Novartis Seeds, Inc., 1998 Farm Technology Adoption Study, available at http://novartis2.planet.net/press_releases/releases/pr_rel_923949083.html.

of learning from farming operations may outweigh the seemingly large differences with specialized goods- or services-producing operations.

The value of information-intensive farming emerges from the integration of information from production, accounting, or marketing facets of the farm enterprise to make better management decisions for the operation as a whole. Computer use in this view is not an add-on to increase the efficiency of individual farming tasks. Rather, the technology provides the central hub of a "farm management information system." A marketing example demonstrates the potential synergies. Farmers examining daily market information will make better decisions regarding the advisability of a forward or cash contract if they have a valid benchmark in the cost of production of the commodity. This, in turn, will require the integration of accounting information with production decisions to comprehensively track the cost of past and anticipated future inputs required to produce the commodity.

Sustainable agriculture provides other examples. A number of computer decision tools are being created to assist farmers in making optimal crop rotation or pasture management plans. These tools require information from all aspects of the farm operation and then help farmers to assess the production, economic, and environmental effects of various strategies. Here again, the technology requires the integration of diverse information. In addition, the results generated by these tools are usually complex, requiring the weighing of various impacts in the decisionmaking process.

A common requirement of information-intensive farming practices is the ability to exploit information from diverse sources to arrive at workable solutions to a variable set of problems. Unfortunately, these skill requirements are not as specific as, say, the ability to read at a ninth grade level or the ability to perform specific procedures in a spreadsheet program. O*Net™ 98, a skills inventory developed by the U.S. Department of Labor, identifies the cognitive skills needed for more than 1,000 occupations. The list of complex problem solving and systems skills in table 3 identify the types of abilities that may be required in information-intensive farming. There have been no formal job content analyses of information-intensive farming. The skill requirements of farmers in the current version of O*Net™ are rudimentary in comparison. However, the importance of these skills is emerging in discussions of precision agriculture and in the use of farm management information systems more generally.

Cognitive Skills in Organizing and Interpreting Information Are Needed

While the effect of computer technology on the skill requirements of off-farm work is a topic of considerable debate, there is one issue that is not contentious. Job security and wages will be greater in work that uses the cognitive skills outlined above compared with work where the technology serves mainly to automate tasks.

Examples from the insurance industry make this distinction more concrete. Automation of insurance claims processing initially reduced skill requirements for clerks. Computers performed calculations and there was little need for clerks to make decisions or use their own judgment. Consequently, automation initially reduced the skill needed to process insurance claims and led to less job satisfaction.

However, the decline in job satisfaction along with the realization that worker skills were being underused caused many firms to re-evaluate the potential benefits of computer technology. The focus shifted from sole interest in increasing productivity (for example, processing more claims in less time) to increasing productivity of a more valuable collection of products. For example, one company described in a book by Richard Murnane and Frank Levy (*Teaching the New Basic Skills*, The Free Press, 1996, pp. 27-28) redesigned its computer system so that every customer service representative could access information about all policies held by an individual customer. The new system gave representatives responsibility to perform multiple tasks that had previously been carried out by more numerous specialized representatives. The system also gave customer representatives latitude to solve complex customer service problems.

Table 3

Cross-functional skills inventory of information-intensive farming

Productive use of information technology requires problem-solving and systems skills

Skill	Description
Complex problem solving skills	Developed capacities used to solve novel, ill-defined problems in complex, real-world settings
Problem identification	Identifying the nature of problems
Information gathering	Knowing how to find information and identifying essential information
Information organization	Finding ways to structure or classify multiple pieces of information
Synthesis/reorganization	Reorganizing information to get a better approach to problems or tasks
Idea generation	Generating a number of different approaches to problems
Idea evaluation	Evaluating the likely success of an idea in relation to the demands of the situation
Implementation planning	Developing approaches for implementing an idea
Solution appraisal	Observing and evaluating the outcomes of a problem solution to identify lessons learned or redirect efforts
Systems skills	Developed capacities used to understand, monitor, and improve socio-technical systems
Visioning	Developing an image of how a system should work under ideal conditions
Systems perception	Determining when important changes have occurred in a system or are likely to occur
Identification of downstream consequences	Determining the long-term outcomes of a change in operations
Identification of key causes	Identifying the things that must be changed to achieve a goal
Judgment and decisionmaking	Weighing the relative costs and benefits of a potential action
Systems evaluation	Looking at many indicators of system performance, taking into account their accuracy

Source: U.S. Department of Labor and U.S. Employment Service. O*Net™ 98 Content Model (<http://www.doleta.gov/programs/onet>).

There are also instructive examples from manufacturing. In a pulp mill that adopted computer technology, job requirements changed from the pragmatic knowledge required of monitoring and maintaining a specific manufacturing process in the plant to a theoretical understanding of how the plant operates. The new system in this plant required production workers to interpret data received from various parts of the plant to evaluate how his or her decisions would affect the operation of the plant as a whole.

An important factor in the decision to modernize the mill was the belief that the new technology would result in all workers at the plant—not just managers—thinking systematically about how to improve the production process. In the words of one worker, “The more I learn theoretically, the more I can see in the information. Raw data turns into information with my knowledge. I find that you have to be able to know more in order to do more. It is your understanding of the process that guides you.” (As quoted in Shoshana Zuboff, *In the Age of the Smart Machine*, Basic Books, 1988, p. 94.)

In these manufacturing and services-producing examples, as with information-intensive farming, the economic activity requires the ability to exploit information from diverse sources to arrive at workable solutions to a variable set of problems. It is this ability of workers to fully exploit the value of information that differentiates the new “Information Economy” from the waning “Industrial Economy.” Computers have been central to this transformation. However, familiarity with computers, by itself, is insufficient. Computers only receive, store, and process data. Workers need cognitive skills to organize these data into valuable information. Workers competent to act on this information are then able to increase the value of services to customers or to produce exactly the good or commodity required by the market most efficiently.

The available data suggest that the integrated use of computer technology across all aspects of farming operations is not widespread. It is less likely that using single task

applications such as computerized bookkeeping is going to develop the problem-solving and systems skills that are becoming increasingly important in the nonfarm economy. However, a significant minority of farms are using computers to bring together data from various aspects of the farm operation to aid better decisionmaking. If the skill of current farmers hinders adopting information-intensive farming, then there is a role for vocational agriculture in developing computer skills.

Computers Reinforce Traditional Systems Approach to Agricultural Education

Not adopting integrated farm management information systems to bring data from all aspects of the farm operation prevents farms from capturing the full decisionmaking benefits of information technology. A traditional strength of agricultural education—to understand the farm operation as a system—is not demonstrated in the single task adoption of the computer. This traditional focus has been noted in discussion on how technical education—preparing students for jobs in industry—needs to be reformed (Stuart A. Rosenfeld, “Building Industrial Competitiveness in Rural Areas,” in S.R. Johnson and S.A. Martin, eds., *Industrial Policy for Agriculture in the Global Economy*, Ames, IA: Iowa State University Press, 1993, pp. 215-16):

[Agricultural education] prepared youth to manage their own businesses; to make decisions about new technologies; to solve technical and business problems; to understand the entire system, from seed to store; and generally to become community leaders....Youth enrolled in vocational agriculture learned the value of innovation, experimentation, and cooperation and learned to make decisions. Youth enrolled in industrial programs learned to operate equipment and follow instructions.

The computer is clearly one tool that can reinforce the traditional emphasis in problem-solving and systems skills in agricultural education. Further, cross-functionality in farm and nonfarm skills suggests that the benefits from the cross-fertilization of agricultural and technical education curricula may be significant. The diversification of student investment in human capital carries the greatest potential benefit. Current students could commit themselves to a program of study without the attendant fear that they are preparing themselves for a career they may never realize. For current farmers, the real cost and risk of investing in a new set of skills may be substantially reduced if development of these skills increases their wages in off-farm employment. However, before these strategies can be acted upon, educational institutions must identify the possible synergies between separate curricula allowing for the development of these cross-functional skills.

The public benefits of information-intensive farming include more efficient input use; better documentation of crop identity, food safety through “traceback” records, environmental compliance; and more efficient output markets leading to a more viable farming sector. A major constraint in realizing these benefits is the skill level of farmers. However, if these same skills can help diversify and increase returns from off-farm employment, there may be significant private incentives for farmers in making this investment. [Tim Wojan, 202-694-5345, twojan@ers.usda.gov]